T.A.S.T.E.

Testing Auditory Solutions towards the improvement of the Tasting Experience

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Abstract

There is a common agreement among researchers about the involvement of multiple senses while taste is being perceived. Also, for restaurants, pubs and similar places there is growing awareness of the significance of the quality of the soundscape and its influence on taste. This project proposes to study the perceptual interaction of taste and audition in the context of the primal activity of feeding. Our aim is also to improve ambient auditory stimulation in psychophysical experiments on tasting experiences using state-of-the-art techniques in engineering acoustics.

Keywords: *Auditory perception, crossmodal correspondences, virtual acoustics, contemporary gastronomy*

1 Introduction

Sound can change taste

There's growing awareness of the significance of the quality of the soundscape in restaurants, pubs and similar places as well as of its influence on people's experiences: research has shown that several psychoacoustic factors play a role [22,23]. The acoustic aspect of comfort is not explicitly taken into account in the overall judgment or commercial valuation of food and drink catering establishments. On the other hand, the contemporary gastronomy community envisions a fully multi-sensorial experience for the near future. This publication refers to a starting project where experimental psychologists, contemporary gastronomes and acousticians are working as one team to study the influence of sound on taste during a gastronomic experience. For this, we defined a four-step process dealing with two main research questions.

How do sonic environments enhance tasting experiences?

First, a team of acousticians will record real gastronomic scenes, during the cooking and eating process. Second, the information acquired is emulated and analysed in a controlled environment, extracting its physical and psycho-acoustical characteristics. Third, psychologists conduct experiments that use the emulated soundscapes for the perceptual analysis of the eating process, aiming to quantify its influence on the perception of taste. Finally, there is the development of a fully customized and controlled artificial immersive-soundscape, where it will be possible to translate the desires of the contemporary cooking field into the sound field.

How does tasting involve all senses?

There's a common agreement among researchers about the importance of the involvement of multiple senses during the tasting experience: The future of gastronomy will involve them all.

2 Research Objectives

The idea proposed is based on the hypothesis that it is possible to improve ambient auditory stimulation in psychophysical experiments using state-of-the-art techniques in engineering acoustics related to tasting experiences, taking laboratory-only single-user tests to in-situ multi-user environments, where external influences should play an important role towards obtaining more reliable results. The study should follow 3 main objectives:

A. The main objective of this project is to establish a link between the acoustic and gastronomic experience. This requires:

1. Establishment of the most relevant (psycho) acoustic parameters related to comfort by systematic mapping of the soundscape in restaurants. This assessment goes along with assessing people's subjective perception by means of interviews and questionnaires in-situ.

2. Transference of laboratory-only studies to in-situ environments.

3. Application of electro-acoustical immersive technology to upgrade single-user cognitive tests to multi-user cognitive studies in a psychoacoustic laboratory.

B. The second objective is to promote the scientific multidisciplinary work, adding engineering and art sciences to experimental psychology studies by:

1. Participating in the current scientific discussions regarding the future of gastronomic experiences.

2. Improvement of the technological access into the Experimental Psychology research field.

3. Generation of new ways to use emerging technology in the field of multichannel recording and immersive soundscapes.

C. The third objective is to offer a knowledge transfer to restaurant ratings worldwide such as the Michelin Guide.

3 State of the Art

A considerable amount of research is focusing on several aspects of the cognitive process and the correlation of senses. While the acoustic conditions in restaurants can be investigated from different points of view, there are no generally accepted methods for the assessment or prediction of restaurant soundscapes [24]. Most of the published literature deals with measurements of 'multi-talker' sound, suggestions of simplified prediction methods and applications of universal design principles or soundscape assessments. Publications in international peer-reviewed journals are predominantly related to investigations of the Lombard effect [19] and the cocktail-party-effect [20], [21]. Some studies have been performed about the pleasantness of restaurant sound in relation to the enjoyment of the meal [23], [22]. The influence of background noise on flavour's perception is constantly being investigated. Woods (2011) concluded [18] that perception of sweetness and saltiness are influenced by white noise. The same happens regarding the perception of crunchiness. The influence of background noise on pleasure while eating has also been investigated by different disciplines [1], [3], [6], [10], [11], [14], [17], [18]. Ferber and Cabanac studied the perception of taste with strong sweet samples and users reported that the flavour perceived was more pleasant with the existence of loud background noise and/or music - over 90 dB [6]. In 2012, Stafford reports that his participants evaluated the perception of alcoholic beverages' flavour ingested under the influence of strong background noise as sweeter [17]. The food industry is constantly investing resources to study the impact of soundscape characterization in food shopping and consuming environments and even in the presentation of products, for example the influence of the sound generated while opening a food package or a can of beverage [13], [18]. Areni and Kim found [1] that

people buy more expensive wine while there is classical music than when there is pop music in the background. In 1997, North stated [10] that consumers are unconsciously influenced by background soundscape while shopping. In his study it was shown that when French music was played with accordion at the wines section, consumers bought more French wine, while when playing German songs consumers bought more German brands. There are studies where crossmodal perception between hearing and taste is analysed. On one hand, Holt-Hansen provided [7] two options in the consumption of beers while observers turned a knob that controlled a tone generator, with the goal of finding the frequency range that "matched" the taste of the specific sample of beer. In this attempt of understanding the correlation of senses taste and hearing, results for the two types of beer fitted in specific different frequency ranges. On the other hand, Crisinel developed [5] a method for crossmodal studies between hearing and tasting, where she uses as gustative sample toffee, since it has defined flavour components of bitterness and sweetness. The experiment studied how subjects characterize flavour under the influence of two different sonic stimuli: one soundtrack was developed to be more congruent with sweet flavour and the other with bitterness. Final results confirm the direct influence of customized sonic stimuli in taste.

Recent publications are focusing on the importance of the implementation of highly controlled laboratory experiments and ways to generate more accurate in-situ data. One of the common conclusions is that what the consumer hears has a role on how we select the food and in our taste perception. Contemporary chefs are having open discussions with the scientific community aiming to define the future of Gastronomic Experiences: The fact that the multi-sensorial eating experience will be further explored is universally accepted. There is a common agreement among researchers and developers about the importance of involving all senses during the gastronomic experience.

4 Methodology Proposal

We aim to merge experimental psychology studies with sound and acoustics engineering (subsequently, when discussing the experiments, we'll be referring to them as psychological experiments). The method consists of three complementary studies, which should be developed chronologically. These studies are:

4.1 Case study with focus group: Taste and sound stimuli preparation

Our experiments require selection and preparation of *(i) taste stimuli* and *(ii) sound stimuli*. The participants of the "Experts" Focus group should consist of: People working in contemporary gastronomy (chefs, cooks), acousticians, soundscape designers, and other stakeholders such as "Michelin" and "Trip advisor" representatives (professionals involved with contemporary gastronomy). The instruments to be used during this study are: Literature review, questionnaires, joint discussions and paper overviews.

(i) Preparation of the Taste stimuli: For this first step, we use the crossmodal correspondences between flavour and sonic information that has been previously reported in two other studies [5], [12]. The focus group must use the information available in these two studies to form three pairs of flavour parameters (e.g. sweet and bitter; salt and acid). These pairs of flavours are the basis of the food samples to be prepared during the next steps of the methodology. Literature suggests that crossmodal auditory modulations of flavour might be more prominent under conditions where different competing tastes/flavours are present simultaneously [8], [15], [16]. Tasting samples have to be able to provide both flavour parameters and they must be located in specific parts of the tongue.

(ii) Preparation of the Sound stimuli: Sound stimuli are being developed by acousticians, soundscape designers and musicians. It is necessary to generate such compositions based on information and tools available [5], [12]. Grounded theory approach is used to grasp additional information from gastronomes (by means of questionnaires and interviews). Methodology on combined taste-sound pairs is based

on crossmodal correspondences between various parameters of musical composition and specific taste/flavour attributes [16], [2], [9]. Each soundtrack produced should be congruent with a flavour parameter involved (e.g., if the pair is sweet and salt, one soundtrack should be congruent with a salty flavour and the other with sweetness).

4.2 Case study with "potential common users": Flavour-soundtracks pair effectiveness

Sound and taste stimuli theories developed from the previous study (4.1) are used for tests in the laboratory, where the expertise from gastronomes, acousticians and psychologist are merged in one experiment. To avoid bias, participants are people not directly involved with acoustics, psychology nor gastronomy (professionally speaking). The main task of this case study is to validate which of the previous proposed samples are most capable of influencing the user's perception.

Selection of participants takes into account: gender, age, education level, exclusion criteria (e.g. obesity), feeding preferences and habits, among others (to be defined). Instrumentation involved consist of a sound reproduction-laboratory, which must be equipped with high soundproofing insulation, the highest standards of sound reproduction quality, acoustical treatment and a sound production system similar to a recording-studio. It is also necessary to have computer-based routines prepared for listening tests. Finally, a computer-based evaluation system developed for psychological studies is used for statistical analysis of subjects' answers. Tasting stimuli created by the focus group are included in this test (4.1). They will be produced inside an existing cooking facility.

Sound Stimuli are presented over headphones at a unique sound level for everybody, at all times. Participants are presented together with small pieces of tasting samples. They are not informed that the samples are exactly the same. Every test begins with one of the soundtracks presented at the same time that a tasting sample is given to the participant. The soundtrack should last less than 1 minute, during which the participants score three different scales. They are asked a question in relation to each scale. Questions asked during the experiment are based on the knowledge acquired from literature and outcomes from the experts group (4.1). Each participant tastes two samples for each soundscape. The order of presentation of the soundscapes is random.

This methodology structure uses as reference the method proposed by Crisinel - *A bittersweet symphony: Systematically modulating the taste of food by changing the sonic properties of the soundtrack playing in the background* [5]. The outcome result of this study is an adaptation and validation of the method used as reference [5], which will also provide the most effective pair of flavours/soundtracks. After this step, it is possible to take the study into the immersive level.

4.3 Immersive study: Virtual Soundscaping

Immersive experiences are developed in laboratory (4.3.A) and in-situ (4.3.B) environments. Not only basic samples are used but more complex eating and sonic environments are presented.

The task group consists of contemporary gastronomes, psychologists, acousticians, sound engineers with experience in soundscape design as well as common users without any involvement in disciplines directly related to this project. To avoid bias sample, they must not be the same participants from the previous studies (4.1 and 4.2). The multichannel sound recording system used for in-situ recordings is equipped with surround microphones with customizable polar patterns to act as a microphone array. The system should be visually discrete, so it can be used in-situ without being obtrusive. The same sonic multichannel reproduction laboratory implemented for case study 4.2 can be used for experiments 4.3. The system must be configured to achieve perfect compatibility with the multichannel recordings. Finally, the same control systems used at study 4.2 for soundtracks playback and psychological data collection can be used for this final case study.

Tasting samples involved in these cases are produced at a cooking facility.

The soundscape emulated during laboratory tests (A) are based on recorded and simulated environments. Recordings are made in different restaurant environments, such as production (kitchens) and degustation (eating) areas. As mentioned before, these high-quality multichannel recordings made in-situ are used for virtual reconstruction of soundscapes. After recording, data acquired is analysed and processed with the goal of reproducing it in a controlled laboratory environment (A). It is important to understand that the surround quality of recordings is determinant for the achievement of an immersive perception.

With the soundscaping system ready, we prepare the experiment from study 4.2 to a group of users under the influence of the virtual sonic environment achieved through the multichannel sonic-immersive system implemented in laboratory (A). First, users are exposed to the same soundtracks from study 4.2 with silent background. Second, they are exposed to the same soundtracks added to the recorded soundscape from the degustation zones of visited restaurants (eating zones). And third, users are exposed to a customized background soundscape, adding recorded elements from the cooking process. This test should follow the same method applied in case study 4.2. The outcome of this part should be a relation between the data obtained in the previous experiment (4.2) and the new data acquired whit users under the influence of the same immersive sonic technology (meaning without headphones). It is important to remind that during tests made at studies 4.3, only the most effective pair of flavours/soundtracks are being presented.

For the next part, users are transferred into a real environment, with the same restaurant eating zones where the sonic samples were registered. (B) The multichannel reproductive system is also taken into the restaurant, permitting the presence of the sonic elements added artificially to the customized soundscapes during in-situ studies. The outcome of this final part should be a relation between the data obtained at in-situ experiences (B) with the data obtained during the immersive test developed at the laboratory facility (A).

Summarizing: At the beginning of our experiment we use specific stimulus categories combining flavour and sound that might have a well-defined influence on the tasting experience (4.1). After stimuli have been validated concerning their effective influence (4.2), we apply those in a real gastronomic environment (4.3), adding custom made soundscapes and collecting relevant data of the real influence of the hearing sense while eating.

5 Impact analysis and future discussion

Research in multisensory perception is being carried out worldwide. Several disciplines are merging forces towards a better understanding of the underlying cognitive processes. Our proposal follows this line of thinking: We believe that this multidisciplinary method could generate accurate results.

Experimental psychologists are working together with neuroscientists and state-of-the-art engineering to provide breakthrough results and better methods for reliable data acquisition. In our case, the objective of applying the expertise of acousticians is a clear example of how merging different disciplines can expand the horizons of scientific research.

The field of acoustics is more and more present in our society every day. We have an actual interest on how the perception of noise influences our social habits and how cultural aspects are directly involved in auditory education. All great research labs worldwide host researchers focusing on acoustic studies, and in Belgium this is not different: KU Leuven is a pioneer in the field [26]; INTEC at University of Gent is a renowned research facility with more than 20 years of experience that is every day more involved with environmental monitoring using sound as its main input data, such as the IDEA project [27].

Our research has also potential impact among other disciplines that invest efforts in studying perception through different angles, such as:

Virtual Reality: The virtual component of our society is growing constantly. We have several technologies for entertainment and services that capitalize on virtual interaction. Since the way we perceive our environment is directly bounded with our senses, to achieve a fully multisensory experience it is necessary to keep on focusing into a better understanding of cognitive processes.

Contemporary Gastronomy: The art of eating is the biggest inspiration for this project and the answers that we will generate may have important applications for contemporary gastronomy. Cooking and tasting with all senses is a true desire of the gastronomic community and with this opportunity we can help into a better understanding of the role of hearing while we taste.

Artificial Intelligence and Computational Neuroscience: Mapping the brain is a common line of research, not only in academic scientific research groups but also at big companies from the private sector, specially the ones involved with computer sciences. The development of artificial intelligence is on the go and big players are dedicating considerable amount of resources into a better understanding of how the human brain works. We can help obtaining relevant data and adding value to such industry fields. Merging top of the line acoustic knowledge and experimental psychology can generate a strong interest for future collaboration between such communities. As mentioned before, the empirical junction between engineers and scientists accelerates research processes and promotes the development of more effective methodologies.

Cognitive Healthcare: A better understanding of the influence of audition while eating should provide interesting and important data that could allow healthcare and mental care applications through cognitive behavioural therapies.

Finally, towards a better understanding of the impact probabilities, we prepared several collaboration opportunities, involving different sectors of society.

Direct contact with one of the most important contemporary gastronomy laboratories worldwide has been established, with the goal of validating the possible impact of our project: The Canroca brothers, owners of the Restaurant "El Celler de Canroca" which is considered to be the best restaurant in the world[1], are considerate researchers in gastronomy. They have actual interest in participating in our multisensory research. They and other world-class chefs were invited to Harvard during 2010, 2011 and 2012 for master classes to share achievements [30]. The Canroca brothers' latest involvement with immersive experiences is called *El Somni* [25], *an overall multi-disciplinarian, analogue, digital, real, dreamy, cybernetic and culinary work*. They combine opera, electronica, poetry, 3D, performing arts, singing, painting, film, music and cookery into a gastronomic master piece, that tries to bring all senses into the eating experience. Although their initial approach uses technology as a simple provider, they could use our results as insights for a better understanding of what they want to achieve and how they can do it with a scientific approach.

Charles Spence, Head of the Laboratory of Crossmodal Research at University of Oxford is interested in this type of proposals. He is an important researcher into perceptive fields, such as auditory perception and audio branding [28]. According to him[2], to have a better understanding of auditory cognitive processes, a constant improvement of acoustic and electro-acoustic technologies involved in psychological experiments is constantly demanded.

Philips Research Labs in Eindhoven has Prof. Raymond Van Ee among his principal researchers, providing psychology/neuroscience expertise to develop devices that use sound in multisensory applications, such as solutions against pain. He is a well-known researcher in the subject of visual cognition and a co-author of this publication. Using

[1] Source: The World's 50 Best Restaurants / 2013

[2] Personal communications with Prof. Charles Spence and the first author during 2012-2013.

multisensory psychophysics, neuroimaging and brain stimulation, he investigates how the human brain voluntarily controls conscious perception and how it is perceptually 'primed'. He is also involved with Wageningen UR in the Netherlands, hosting pioneers related to rethinking food consumption [29]. Along with Sodexo, Noldus IT and Kampri Group, this research facility implemented an experimental "Restaurant of the future", allowing close observation of consumers' eating and drinking behaviour. Furthermore, Philips Design and Arzak Restaurant are working together since 2010 developing interactive tableware, which stimulate senses through light, sound vibration and electrical current. Since the release of the first series of interactive plates at Madrid Fusion 2010, the collaboration has looked at ways of altering the perception and enjoyment of food and drink by subtly stimulating adjacent sense at the same time. [31], [32]

Major companies such as Unilever, Nestlé, Coca-Cola, among others, are world players that are constantly looking for new data. We believe that once we have primary data, it will be possible to propose joint research.

Acknowledgments: Since our project is at its early beginnings, our presence at The 10th International Symposium on Computer Music and Multidisciplinary Research (CMMR) is due to the fact that we wish to expand our network. We are mainly interested in spreading the concept and looking for to catch attention of potential collaborators, especially in the fields of music composition, sound design and immersive audio-technologies.

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